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Exhaust pipe insulated by an air gap, and method for producing the same

The invention relates to a bent exhaust pipe insulated by an air gap, and to a method for producing the same.

In exhaust systems of modern internal combustion engines which are equipped with a catalytic converter, use is increasingly being made of double-walled pipes which have an outer pipe and an inner pipe, with an insulating air gap being formed between the outer pipe and the inner pipe. Pipes of this type are what are referred to as pipes insulated by an air gap (IAG). The air gap between the outer pipe and the inner pipe advantageously acts as heat insulation, which, owing to the poor transfer of heat from the inner pipe to the external surroundings, rapidly brings the exhaust system and the catalytic converter connected thereto to its operating temperature.

In conjunction with units being arranged, for example in the engine compartment of a motor vehicle, as compactly as possible, it is endeavored in general to design the abovementioned double-walled pipes in bent form, so that a space-saving installation in the region of the engine compartment can be obtained. Without additional auxiliary means it is currently not readily possible to bend an IAG pipe. The difficulty resides in maintaining the required gap size between the pipe walls. The pipe walls must not touch after the bending and the gap size between the inner pipe and the outer pipe must not undergo a serious change, such as, for example, due to pipe collapse and the like.

In known bending processes, this requirement is met by inserting additional materials in loose form which are

placed between inner pipe and outer pipe. In this case, use can be made, for example, of the materials sand, steel balls, low-melting alloys, ice and the like. The disadvantages in this regard reside firstly in the outlay, for example the supply of power to melt ice in order, after the IAG pipe is formed, to remove the inserted media again from the gap. Secondly, there is a disadvantage in the excessive soiling of the working environment by the emerging media. In particular if steel balls lie around on the floor, there is a considerable potential risk to people by them sliding on the balls. A further disadvantage is that residues of the additional material (in particular steel balls) may remain in the bent pipe and, during subsequent operation, may therefore cause malfunctions of units, such as, for example, of the catalytic converter or a turbocharger. Similarly, undesirable noise emissions may occur due to remaining residual media.

The publication DE 102 01 594 A1 describes a method for producing a bent double-walled IAG pipe. In this pipe, the gap between the inner pipe and the outer pipe is completely filled by a spacer layer. If the spacer layer is composed of a plastic or of a low-melting alloy, the removal of the spacer layer is obtained by burning or melting it out. However, an IAG pipe produced according to the method of this publication is subject to the disadvantage that the gap between the inner pipe and the outer pipe is completely filled by the spacer layer and accordingly a large quantity of material is to be removed after the production of the component.

The invention is based on the object of providing a bent double-walled component and a method for producing the same, in which the positioning of an intermediate piece in the pipe composite structure formed from the inner pipe and the outer pipe requires a low outlay and

the removal of the intermediate piece is readily possible.

According to the invention, the object is achieved by a method with the features of claim 1, and furthermore by a component with the features of claim 14. Advantageous developments of the invention are the subject matter of the dependent claims.

By means of the method according to the invention, a bent double-walled component can be produced, in which an intermediate piece only fills part of an intermediate space, which is provided between the inner pipe and the outer pipe, in the axial direction of the component. In this case, the thickness of the intermediate piece is essentially matched to the distance which exists between an outer surface of the inner pipe and an inner surface of the outer pipe. The intermediate piece is expediently only positioned at a location in the intermediate space of the component where it is required for bending the composite structure formed from the inner pipe and the outer pipe in order to prevent a pipe collapse and the like. Put in other words, the formation of collapsing points, bucklings and the like during the bending of the composite structure is prevented at the location where the intermediate piece is situated between the inner pipe and the outer pipe. During the bending of the component or of the entire pipe composite structure, the intermediate piece therefore ensures that the inner surface of the outer pipe is adequately supported against the outer surface of the inner pipe, so that the gap size or the distance between the inner pipe and the outer pipe remains essentially constant.

An essential feature according to the invention is that the intermediate piece does not completely fill the intermediate space between the inner pipe and the outer

pipe. This can take place in an advantageous embodiment by the intermediate piece being designed in the form of a ring which is either placed onto the inner pipe or is placed into the outer pipe before the bending of the composite structure. If the component has a plurality of curvatures in the axial direction, in the case of the method according to the invention a plurality of intermediate pieces are advantageously arranged in the form of rings along a longitudinal axis of the component, so that a ring is positioned in each case on a corresponding bending point in order to prevent a pipe collapse at this point. The same advantageous effect can be obtained by an intermediate piece which is designed in the form of a spiral which extends along a longitudinal axis of the component. In comparison to a plurality of rings, a spiral of this type affords the advantage of further simplified handling and a correspondingly shortened installation time.

Furthermore, the provision of an intermediate piece, for example in the form of an individual ring or a spiral, affords the advantage that, after an internal combustion engine in which the double-walled component is inserted is put into operation, the high exhaust temperatures and the resultantly induced thermal destruction of the intermediate piece mean that only a small quantity of gas has to escape from the intermediate space. There is therefore only a small if any "enrichment" of the exhaust gas flow, which is guided in the inner pipe, of the internal combustion engine by the quantity of gas which arises because of the burning of the intermediate piece.

According to an advantageous alternative embodiment, the intermediate piece may also be formed from a coating of an inner pipe which has already been manufactured. In comparison to an installation of a separate ring or a separate spiral, this affords

significant advantages, with regard to a continuous manufacturing process, in the form of a further-reduced outlay on installation.

In an advantageous development of the invention, the intermediate piece is produced from a plastic. Particularly suitable for this is a plastic made from polyethylene for which a residue-free burning is ensured as a result of the high exhaust temperature. Damage, for example to the catalytic converter through which the exhaust gas flow is exclusively conducted, due to residues of the burnt intermediate piece therefore does not occur. In the same manner, other plastics which, during their thermal destruction or burning, are converted exclusively into reusable cleavage products are also suitable for the intermediate piece, as a result of which damage to the catalytic converter or the like is prevented.

In what is referred to as an IAG pipe, the outer pipe is generally of a design tight to exhaust gas. In an advantageous development of the invention, the inner pipe is connected to an adjacent part of the exhaust system by means of a sliding fit. Such a sliding fit firstly ensures compensation for thermal stresses which arise due to the very severe differences in temperature during operation of the internal combustion engine in comparison to the inoperative state. Secondly, the gas formed by the burning of the intermediate piece as a consequence of the exhaust temperature of some hundred degrees Celsius can readily pass through the sliding fit from the intermediate space into the inner pipe in order then to be output to the outside together with the regular exhaust gas flow, for example through the catalytic converter. The residue-free burning of the intermediate piece therefore creates the desired complete air gap between the inner pipe and the outer pipe which ensures the required thermal insulation for

the double-walled component during the further operation of the internal combustion engine.

Further advantages and refinements of the invention emerge from the description and the attached drawing.

It goes without saying that the features of the invention which are mentioned above and those which have yet to be explained below can be used not only in the respectively stated combination but also in other combinations or on their own without departing from the scope of the present invention.

The invention is illustrated diagrammatically below in the drawing with reference to an embodiment, which is to be understood as being only by way of example, and is explained in more detail below with reference to the drawing.

Figure 1 shows a double-walled pipe according to the invention in a bent state.

Figure 2 shows various embodiments of a pipe end in the region A of figure 1.

Figure 3 shows a double-walled pipe according to the invention with an intermediate piece in a non-bent state.

Figure 4 shows the pipe from figure 3 in a bent state.

Figure 5 shows a double-walled pipe according to the invention with an alternative intermediate piece in a non-bent state.

Figure 6 shows the pipe of figure 5 in a bent state.

Figure 7 shows the double-walled pipe according to the

invention in a state in which it is fitted in an exhaust system by means of a sliding fit.

Figure 1 shows a lateral cross-sectional view of an embodiment of a double-walled pipe 10 according to the invention in a bent state. In detail, the pipe 10 has an inner pipe 11 and an outer pipe 12 which are arranged coaxially with each other. The outside diameter of the inner pipe 11 is selected to be substantially uniformly smaller along the entire axial extent I of the pipe 10 than the inside diameter of the outer pipe 12, with the result that an intermediate space 13 is formed between the inner pipe 11 and the outer pipe 12. In this case, an outer surface 14 of the inner pipe 11 is spaced apart essentially uniformly by a distance d from an inner surface 15 of the outer pipe 12.

The bent state of the pipe 10 that is shown in figure 1 is expediently obtained by means of an intermediate piece (not shown in figure 1) which is placed into the intermediate space 13 before an appropriate bending or forming of the pipe 10. An intermediate piece of this type can advantageously be produced from a thermoplastic, such as, for example, polyethylene. If, after its completion, the pipe 10 is fitted in an exhaust system of an internal combustion engine, the plastic intermediate piece burns in a residue-free manner under the effect of the high exhaust temperature which usually assumes a value of some 100°C. As a result, a continuous air gap is produced by the burning of the intermediate piece in the intermediate space 13, thus producing the desired heat insulation of the inner pipe 11. The pipe 10 shown in figure 1 is shown in a state in which the intermediate piece has already been burnt in a residue-free manner.

The manner in which the pipe 10 is brought by means of

the intermediate piece into its bent state is explained in detail below with reference to figures 3 to 6.

First of all, the inner pipe 11 and the outer pipe 12 are provided preferably in rectilinear form. An intermediate piece 16 in the form of a plastic ring is subsequently either placed onto the outer surface 14 of the inner pipe 11 or placed into the inner surface 15 of the outer pipe 12. In order to prevent an undesirable slipping of the plastic ring 16 during the further manufacturing sequence, the ring preferably has a matching size with regard to the outer surface 14 of the inner pipe 11 or to the inner surface 15 of the outer pipe 12.

In a next step, the inner pipe 11 and the outer pipe 12 are brought together to form a composite structure, with the inner pipe 11 and the outer pipe 12 now being spaced apart from each other at a defined distance d by the ring 16. The thickness of the ring 16 is suitably matched to the respective dimensions of the inner pipe 11 and of the outer pipe 12, so that the two pipes can readily be brought together without jamming or the like together.

The ring 16 is preferably produced from a thermoplastic, such as, for example, polyethylene, which firstly results in favorable production costs. The ring 16 is placed into the intermediate space 13 between the inner pipe 11 and the outer pipe 12 at a location at which the pipe 10, which is still rectilinear, is subsequently subject to a bending or forming process. With regard to the bending of the pipe 10, the composition of the ring 16 from a plastic material ensures that the ring 16, owing to its elasticity, does not provide an excessive resistance to the deformation. Furthermore, the intermediate ring 16 is of such dimensional stability that it does not yield

to the acting forces and accordingly is not massively deformed.

The composite structure which is formed by the inner pipe 11 and the outer pipe 12 being joined together can be transferred, for example, by means of a conventional CNC bending with suitable mandrel supports and the like into the bent state which is shown in figure 4 in a lateral cross-sectional view. During the bending of the pipe 10, the intermediate ring 16 remains dimensionally stable with regard to its thickness, so that the inner pipe 11 remains approximately uniformly spaced apart from the outer pipe 12 by the distance d even in the section of the pipe 10 which is now bent. During the course of the bending operation, the inner surface 15 of the outer pipe 12 is reliably supported with respect to the outer surface 14 of the inner pipe 11 by the ring 16. The intermediate ring 16 therefore contributes to the required gap size d in the pipe 10 also being maintained in its bent section. In the course of the bending of the pipe 10, the intermediate ring 16 prevents an impermissibly high pipe collapse, bucklings and the like, which would otherwise mean that a constant gap size between the inner pipe 11 and the outer pipe 12 would no longer be ensured.

If, in its end state, the pipe 10 has a bent section at a plurality of points, then a plurality of intermediate rings 16 is provided before the bending of the pipe 10. In detail, a respective intermediate ring 16 is arranged in each section of the pipe 10 or of the intermediate space 13 that is subsequently subject to a bending operation. This ensures in an efficient and simple manner that, as a result of the intermediate ring 16 positioned in those sections of the pipe 10 which are bent, an impermissibly high pipe collapse and the like does not occur therein.

Instead of an individual intermediate ring 16 or a plurality of rings, the intermediate piece may alternatively be designed in the form of a spiral 16'. Figure 5 shows the pipe 10 in a lateral cross-sectional view in which an intermediate piece in the form of a spiral is placed into the intermediate space 13. The spiral 16' is suitable in particular for the case in which the bent section of the pipe 10 extends over a relatively long region in the axial direction of the pipe 10. In this case, a pipe collapse or the like can therefore also be reliably prevented. Furthermore, in comparison to a plurality of individual rings, the spiral 16' is distinguished by substantially simplified handling, which results in a shortened installation time and therefore in a reduction in costs. In figure 6, the pipe 10 from figure 5 is shown in a bent state. As already explained above, as a result of the spiral 16' a constant distance d between the inner pipe 11 and the outer pipe 12 is ensured in the bent section of the pipe 10.

As an alternative to providing the intermediate piece in the form of a ring or a spiral, the inner pipe 11 may also be provided with a coating in that section in which the pipe 10 which is to be produced is in the end bent, the thickness of which coating essentially corresponds to the desired distance d between the inner pipe 11 and the outer pipe 12. This coating is expediently also composed of a plastic, which, owing to the elasticity of this material, readily permits a deformation in the bent section.

A substantial advantage of the invention is that the bent pipe 10 does not need any further treatment in order to remove the intermediate piece. In the event of the pipe being used in an exhaust system or the like of an internal combustion engine, the high exhaust temperature and the correspondingly produced heating of

the pipe 10, in particular of the inner pipe 11 in which the exhaust gas is guided, causes the intermediate piece, if the latter is produced from a plastic, to be burned. With regard to undesirable damage to a unit arranged in the exhaust system, such as, for example, a catalytic converter, a turbocharger or the like, it is of substantial importance that the intermediate piece burns in a residue-free manner. A suitable plastic which fulfils this requirement is provided, for example, by a polyethylene. Furthermore, the intermediate piece may also be formed by different plastics which ensure a residue-free burning in the same manner.

It is explained below with reference to figure 7 how the gases which are produced by the burning of the intermediate piece 16, 16' escape from the intermediate space 13.

In general, an exhaust system of an internal combustion engine is subjected to considerable temperature fluctuations which result in a thermal expansion of the individual components of the exhaust system. To compensate for these temperature fluctuations and the resultantly caused thermal stresses, it is known to connect adjacent components or pipes of the exhaust system to each other by means of what is referred to as a sliding fit. In such a sliding fit, one pipe is merely pushed into another pipe, with the result that thermal stresses can be compensated for by a sliding movement of the one pipe relative to the other pipe.

Figure 7 shows a lateral cross-sectional view of part of an exhaust system. In this case, an end section of the inner pipe 11 is fitted to an adjacent pipe 17 by means of a sliding fit 18. This sliding fit 18 is explained in detail below.

An exhaust gas flow which is produced by an internal combustion engine or the like is entirely guided in the inner pipe 11. In general, it is of great importance in the case of the double-walled pipe 12 that the outer pipe 12 is designed to be absolutely gastight in order to prevent exhaust gas from escaping into the atmosphere or to prevent impermissible noise emissions or the like. In the illustration shown in figure 7, the direction of flow in which the exhaust gas is guided in the inner pipe 11 runs from the left to the right and is accordingly indicated by an arrow E. The inner pipe 11 is inserted at its end 20 into the adjacent, further pipe 17. The pipe 17 is designed to be slightly larger in its diameter than the inner pipe 11 and therefore surrounds the end section 20 of the inner pipe 11. In this case, the dimensions of the inner pipe 11 and of the pipe 17 are suitably selected in such a manner that a small gap s is formed in the region in which the respective end sections of the pipes overlap. During the operation of the internal combustion engine, the direction of flow E has the effect that, as a result of what is referred to as an "entraining effect", a suction effect arises from the intermediate space through the gap s into the interior of the pipe 17. Put in other words, air particles are sucked into the pipe 17 from the intermediate space 13 through the gap s by the explained suction effect and are transported by the rest of the exhaust gas flow further to the right in figure 7, for example in the direction of a catalytic converter or the like.

By means of the above-explained suction effect on the end section 20 of the inner pipe 11, it is ensured that a gas which arises as a result of the burning of the intermediate piece 16, 16' in the intermediate space 13 can escape in a suitable manner through the gap s which is formed in the sliding fit 18, with the result that this gas is transported away together with the rest of

the exhaust gas flow. Accordingly, by means of the operation of the internal combustion engine, a burning of the intermediate piece 16, 16' is brought about as a consequence of the high exhaust temperatures without, for example, an additional supply of power in order to melt the intermediate piece, or similar special measures.

With reference to figure 2, various embodiments are explained in which the respective end section of the pipe 10 can be formed. In figures 2a to 2c, possible arrangements of that end section of the pipe 10 which is shown by A in figure 1 are explained in detail.

According to the embodiment of figure 2a, the end section of the pipe 10 can be designed in an "open" variant, in which there is no metallic contact between the inner pipe 11 and the outer pipe 12. Accordingly, an adjacent part of the exhaust gas train is to be designed in the same manner, with the result that a sealing contact is produced between the respective pipe points.

According to an alternative embodiment shown in figure 2b, the inner pipe 11 is increased in diameter or "turned out in a tulip-shaped manner" at its end, as a result of which contact is produced between the inner pipe 11 and the outer pipe 12.

In the further alternative embodiment shown in figure 2c, the outer pipe 12 is reduced in its diameter, so that contact is produced between the two pipes in the same manner as in the embodiment of figure 2b. In both embodiments of figure 2b and figure 2c, a welding point can additionally also be placed at the contact point of the two pipes in order to prevent a displacement of the pipe ends due to the bending operation.

The residue-free burning of the plastic intermediate piece is explained once again below.

During operation of the internal combustion engine, the temperature of the exhaust gas guided in the inner pipe 11 readily reaches a value of 500°C and above, with at least the inner pipe approximately assuming the same temperature. Since the plastic intermediate piece, as explained above, is in contact with the inner pipe, during operation of the internal combustion engine, when the hot exhaust gas flows through the inner pipe, the plastic is burned, since the exhaust temperature mentioned is substantially greater than the destruction temperature of the plastic. In the case of a polyethylene, the polymeric material is converted into its low-molecular cleavage products, i.e. carbon and hydrogen. These low-molecular cleavage products are completely harmless to a catalytic converter, and so the gases of the burned plastic, as explained above, can readily be carried away together with the regular exhaust gas flow through the inner pipe 11 and subsequently through the catalytic converter (not shown) to the outside. Other plastics, in particular thermoplastics, which, when they are being burned, merely release low-molecular cleavage products which are completely harmless with regard to a catalytic converter or the like are also suitable in the same manner.

The method according to the invention for producing a bent double-walled component is distinguished in that a precisely defined positioning of an inner pipe relative to an outer pipe can be obtained in a simple manner by an intermediate ring, a plurality of intermediate rings, a spiral or a corresponding coating of the inner pipe, this intermediate piece/these intermediate pieces effectively preventing a pipe collapse or the like during the bending of the composite structure formed

from the inner pipe and the outer pipe. The intermediate piece is expediently formed from a plastic, so that, during operation of an internal combustion engine, no special measures have to be taken in order to remove the intermediate piece, since the latter burns in a residue-free manner as a consequence of the high exhaust temperatures. By providing just one ring or a plurality of individual rings or a spiral, it is advantageously ensured that only a small quantity of material of the intermediate piece is to be burned, as a result of which the regular exhaust gas flow which is guided within the inner pipe is only slightly "enriched" by the gas produced by the burning of the intermediate piece. Moreover, as a result of the quantity of material only being small, a very rapid burning and therefore a speedy removal of the intermediate piece come about, after which, in a correspondingly rapid manner, a desired continuous insulating air gap is produced between the inner pipe and the outer pipe.